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INITIAL GERMINATION AND SURVIVAL OF LODGEPOLE PINE ON PREPARED SEEDBEDS

by

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ABSTRACT

Nine methods of seedbed preparation were tested on the Gallatin and Targhee National Forests to determine which method provided best conditions for germination and survival of lodgepole pine. Thorough preparation of seedbed, directed towards conserving soil moisture, considerably improved both germination and survival.

Adequate natural regeneration of lodgepole pine (Pinus contorta Dougl.) is usually obtained in Rocky Mountain stands by careful handling of logging slash bearing serotinous cones.[2 3] Despite this precaution, clearcuttings in parts of southwestern Montana and eastern Idaho have not regenerated adequately. Furthermore, when the methods used to regenerate lodgepole pine in central Montana are successful, they often produce a superabundance of seedlings. Noncommercial thinnings are then needed to prevent the young stands from stagnating. These facts pointed out a need for new information on effects of various methods of seedbed preparation on germination and survival of lodgepole pine. When conditions affecting germination and survival are better understood, then treatments can be recommended that will not only increase success of seedling establishment but also will reduce overstocking.

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[2] Boe, K. N. Regeneration and slash disposal in lodgepole pine clear cuttings. Northwest Sci. 30(1): 1-11, illus. 1956.

[3] Tackle, David. Regenerating lodgepole pine in central Montana following clear cutting. U.S. Forest Serv. Res. Note INT-17, 7 pp., illus. 1964.

Nine methods of seedbed preparation were tested on three physiographic areas where adequate regeneration of lodgepole pine has been difficult to obtain on the Gallatin National Forest near West Yellowstone, Montana, and the Targhee National Forest near Island Park, Idaho. Plots were sown with treated lodgepole pine seed. Weekly and biweekly seedling counts were made on 2-milacre plots, testing nine prepared seedbeds at each replication. This paper presents the results obtained during the first growing season.

METHODS

Experimental Design and Study Areas

Nine seedbed treatments were replicated three times in a randomized block design on each of three physiographic areas (table 1).

Table 1.--Location and characteristics of experimental areas

Area and National Forest	Soil type	Slope	Elevation	Year logged	Year slash treated
		Percent	Feet		
West Yellowstone, Gallatin N.F.	Alluvial obsidian sands and gravel	<5	6,700	1957	1958
Island Park, Targhee N.F.	Alluvial rhyolitic loam over cobble	5 to 15	6,500	1959	1960
Moose Creek Plateau, Targhee N.F.	Gravelly clay loam developed from various volcanic rocks	5 to 15	7,800	1961	1961

Treatments

Rectangular 2-milacre plots (6.6 × 13.2 feet), oriented with their long axes in a north-south direction, were treated during the summer of 1961 as follows:

1. Check. Natural undisturbed duff.

2. Burned. Areas where slash had been piled and burned.

3. Disked. Plots were disked in an east-west direction by a lightweight disk harrow.

4. Scalped. Area was stripped of all vegetation by using a shovel to simulate scalping by a dozer blade.

5. Scalped and cultivated. Area was stripped of all vegetation and the soil was loosened to a depth of 6 inches by using a shovel.

6. Scalped, cultivated, and sprayed. Area was treated as in treatment 5 and in addition was sprayed with dalapon grass killer (2,2-dichloropropionic acid) at a rate of 16 pounds per acre.

7. Simulated brushblade scarification. Quadrat was partially scalped (about 90 percent of the area) of vegetation, and small trenches (about 16 inches apart and 1 to 3 inches deep) were dug with a mattock in an east-west direction.

8. Furrowed. Trenches 3 to 4 inches deep were dug in an east-west direction leaving a sharp, perpendicular edge to the south to provide maximum shade to seedlings in the trench.

9. V-shape trenched. Trenches 3 to 4 inches deep were dug in an east-west direction leaving a 45-degree angle to both the north and south to provide seedlings with minimal shade.

Seeding

The lodgepole pine seed used in this study were collected on the Targhee National Forest in 1958 at an elevation of 6,300 feet. Seed were 55-percent viable (standard germination test) and were treated with 17.5 percent anthraquinone and 2.5 percent Endrin (clean, untreated seed basis) to repel birds and rodents. The seed were sown in October 1961. A large amount of seed (2,200 viable seed per milacre) was used to insure an adequate seedling catch and thereby permit statistical analysis of data from all treatments. Failure on adverse seedbeds would have hindered analysis of data.

Measurements

Seedling counts were made weekly during the early part of the season and biweekly after both germination and mortality declined. Mortality was recorded by numbers of seedlings, week of germination (colored toothpicks beside seedlings denoted week of germination), and apparent cause of mortality. Seedling counts were made on the central milacre (4.4 × 9.9 feet) of the 2-milacre plot to avoid an "edge" effect and to provide an area for sampling soil moisture. Soil moisture was determined six times during the season at 2-inch intervals to the 6-inch depth and at 6-inch intervals to the 18-inch depth.

A weather station was located at one replication on each physiographic area and was equipped with a recording rain gage, hygrothermograph, soil thermograph, maximum and minimum thermometers, and a totalizing anemometer. Weather data were recorded at weekly intervals. Maximum soil surface temperatures were measured on each plot using both Tempils° and a thermograph at each weather station. The soil thermograph was calibrated using a potentiometric pyrometer.

RESULTS

Germination

Although more than 90 percent of the seedlings had germinated by early July (figs. 1 and 2), some germination continued throughout the remainder of the summer. However, late season germination only partially offset mortality; it did not add appreciably to the final count of seedlings in September. Less than 2 percent of the total germination occurred during each examination period after the middle of July.

On the Moose Creek Plateau, 91 percent of the seedlings germinated within a 2-week period (fig. 2). The plots were examined carefully on June 27, but no seedlings were present; in fact, some plots still had snow on them (in the previous week 1 to 2 feet of snow covered the entire area). On July 5, 1 week later, 74 percent of the seedlings had germinated. By July 11 the peak of germination had passed; only 2 percent germinated during the third week of the observation period. Apparently, as soon as the snow cover left, conditions were favorable for immediate germination on this high area.

Germination on the two lower areas (West Yellowstone and Island Park) did not occur as rapidly as at Moose Creek Plateau. Unfortunately, seedling counts were not made soon enough to determine the start of germination on these two areas. However, general observations and air temperature records indicate that peak germination probably occurred during the last 2 weeks in June. Bates[4] stated that the optimum basic temperature for lodgepole pine germination is about 70° F. (21° C.). Air temperatures reached 70° F. on these study areas about the middle of June, following snowmelt during the early part of May.

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[4] Bates, C. G. The production, extraction, and germination of lodgepole pine seed. U.S. Dept. Agr. Tech. Bull. 191, 192 pp., illus. 1930.

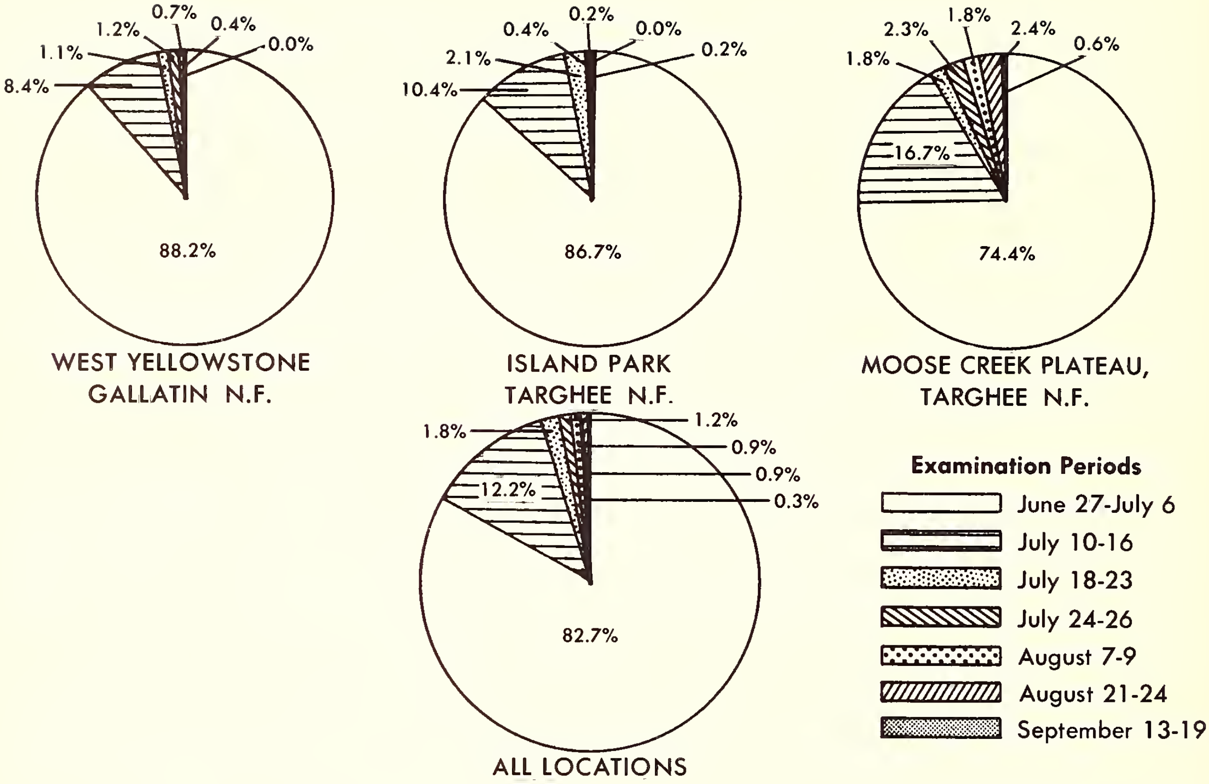

Figure 1.--Germination by date and area, Gallatin and Targhee National Forests, 1962.

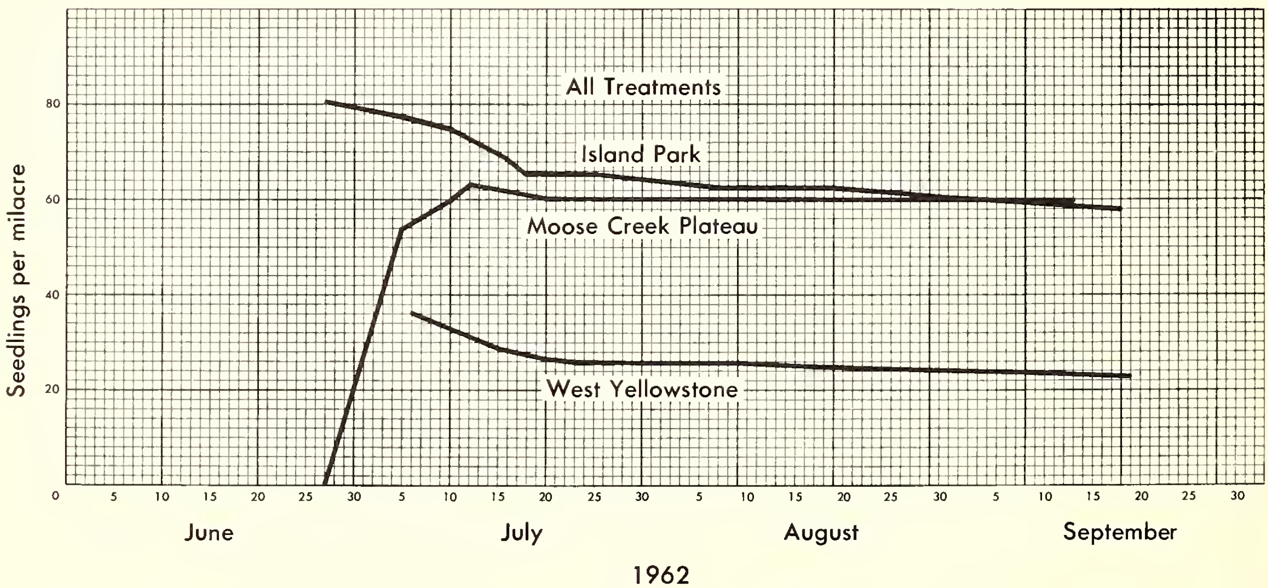

Figure 2.--Average number of seedlings per milacre from all treatments, by area, Gallatin and Targhee National Forests, 1962.

Mortality

As with germination, mortality occurred early in the season (fig. 3). Only traces of precipitation fell between June 22 and July 13, when most of the mortality occurred. More than an inch of rain fell during a timely storm that began on July 13. On the two lower sites, more than 70 percent of the mortality occurred by the middle of July (fig. 3). On the Moose Creek Plateau approximately half of the mortality occurred during the first 2 to 3 weeks after germination began.

Approximately 90 percent of the mortality was attributed to drought. Seedlings recorded as "drought mortality" were shriveled and dry without sign of mechanical injury. Most were upright and brown in color. Some were blown to one side and broken because of the brittleness of their stems. Other agents were gophers, birds, soil movement, heat injury, and hail. Unknown factors accounted for 7 percent of the losses.

Heat injury, or stem necrosis by insolation, did not occur as frequently as had been expected. Soil surface temperatures commonly exceeded 138° F. (59° C.) for several hours on all seedbeds, and temperatures from 150° to 163° F. (65° to 75° C.) were observed occasionally on surfaces of the check and burned treatments.

Survival was not correlated with age of seedling, as had been expected; i.e., late germinating seedlings did not necessarily succumb more readily than early germinating seedlings. The correlation coefficient for percentage of survival over age of seedlings was only 0.064.

Late in the season, mortality increased slightly (fig. 3). Following cessation of heavy rains during the middle and latter part of July, soil moisture declined rapidly. Rainfall during late August and early September was light, and daytime temperatures remained relatively high. Although root growth was not studied in detail, excavations of a few seedlings less than 8 weeks old on August 2 showed that roots on the trenched and scalped treatments had grown 5 to 6 inches, compared with about 4 inches on the check plots. Apparently, near the end of the season root growth was not sufficient to maintain some seedlings through the dry period, when even the 12- to 18-inch depth was affected.

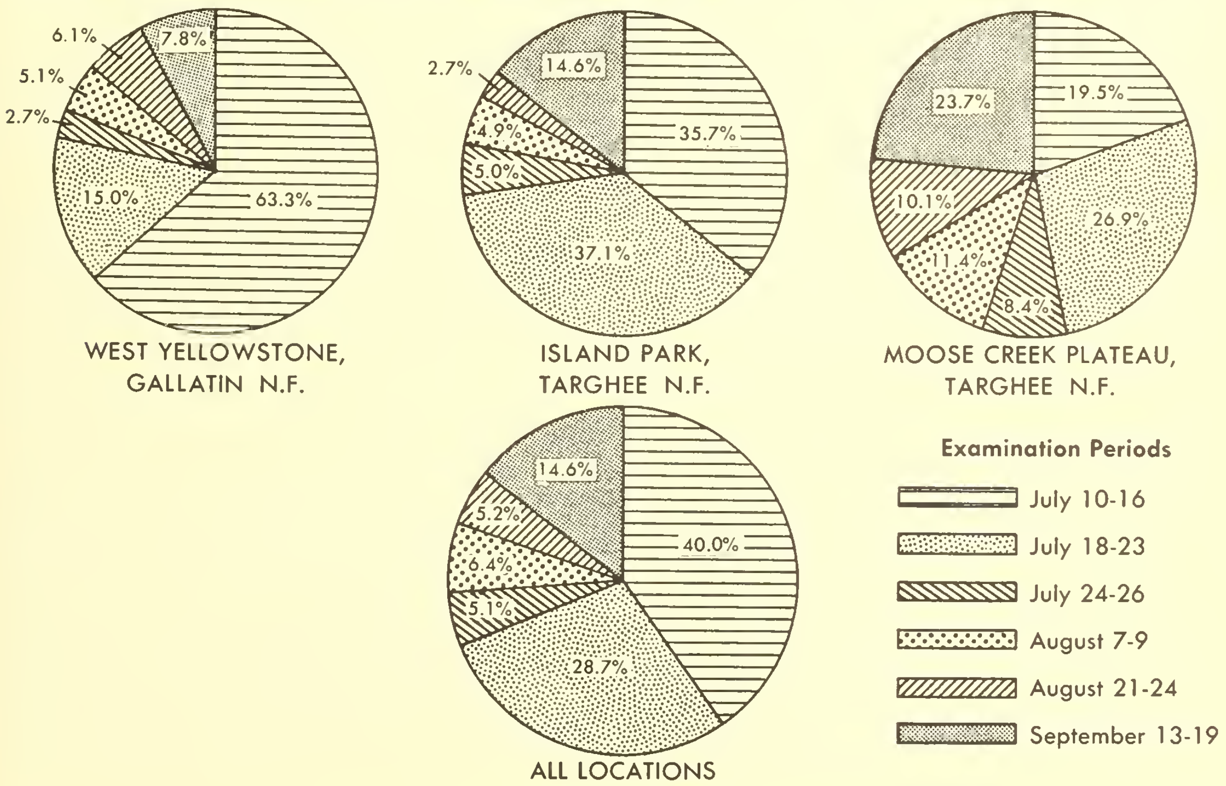

Figure 3.--Seedling mortality by date and area, Gallatin and Targhee National Forests, 1962

Survival

The number of seedlings per milacre surviving the first growing season was significantly greater on each of four thoroughly prepared seedbeds than on the check treatment (table 2). Three of the four most successful treatments had some form of east-west-oriented trenching. The furrowed, V-shape trenched, and simulated brushblade treatments were all more effective than other treatments; the deeper trenches provided the best environment.

The amount of seed used in this study was large enough to insure that some seedlings would survive even the more adverse treatments. In table 2, to make the results more meaningful to forest managers, the numbers of seedlings per milacre have been converted to ratios of viable seed/seedlings based on September counts of survival. For example, 278 viable seed were required to establish one seedling on the burned treatment, compared with only 26 seed on the furrowed treatment.

Table 2.--Average number of seedlings per milacre and seed/seedling ratios by treatment and area, Gallatin and Targhee National Forests, September 1962

Seedbed treatments	West Yellowstone	Island Park	Moose Creek Plateau	All locations[1]	Viable seed/seedling ratio
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Burned	14.7	5.0	4.0	7.9	278
Check	6.0	16.7	3.0	8.5	259
Disked	3.3	27.3	44.7	25.1	88
Scalped	11.3	74.7	15.0	33.7	65
Sprayed	17.0	68.3	52.7	46.0	48
Cultivated	21.7	72.3	105.0	66.3	33
Brushblade	19.7	100.3	79.3	66.4	33
V-shape trenched	67.0	78.0	98.7	81.2	27
Furrowed	48.3	81.3	118.7	82.8	26

[1] Any two means of the "All locations" column not included in the same vertical bracket are significantly different at the 95-percent level of probability.

Treatments that provided best conditions for production of maximum number of established seedlings by September were not necessarily the best treatments for survival. For production of a maximum number of established seedlings by September, a treatment had to provide an environment at once favorable to germination in the spring and also favorable to survival during harsh climatic conditions in summer. The "sprayed" treatment ranked high in terms of percentage survival (table 3), but did not rank as high in terms of established seedlings per milacre in September (table 2), presumably because initial germination was low. No significant differences in survival occurred among any of the trenching-type treatments or the scalping-type treatments (table 3). Trenching apparently provided better conditions for germination than scalping, but did not increase survival.

Table 3.--Percentage survival[1] of total germinates by treatment and area, Gallatin and Targhee National Forests, September 1962

Seedbed treatments	West Yellowstone	Island Park	Moose Creek Plateau	All locations[2]
	Percent			
Check	19.3	29.7	43.4	30.8
Burned	39.4	17.6	54.6	37.2
Disked	15.9	46.7	74.7	45.7
Brushblade	18.9	72.9	77.2	56.3
Scalped	39.1	64.5	70.9	58.2
Furrowed	52.8	59.8	83.9	65.5
V-shape trenched	81.9	62.8	74.6	73.1
Sprayed	64.6	88.1	83.9	78.9
Cultivated	88.8	79.7	85.6	84.7

[1] Percentages were transformed to arcsin $\sqrt{\text{percentage}}$ for statistical analysis.

[2] Any two means of the "All locations" column not included in the same vertical bracket are significantly different at the 95-percent level of probability.

DISCUSSION AND CONCLUSIONS

The first growing season of the study (1962) was relatively cool and wet.[5] At West Yellowstone the maximum recorded temperature in 1962 was 86° F. (30° C.) compared with 96° F. (36° C.) in 1961 and a 91° F. (33° C.) average recorded maximum for the previous 12 years. Precipitation in July and August was 4.36 inches compared with a 30-year average of 2.44 inches. More than 60 percent of this additional moisture fell during the storm on July 13 at a very critical time. Mortality declined rapidly following this rain, and roots grew to a depth where even later in the season soil moisture was adequate for survival of most seedlings. If there had been no rain during this critical period, differences among seedbed treatments could have been greater. A relatively hot, dry season (such as 1961) would have shown greater differences in survival, and probably would have killed more late germinates.

Differences in survival of seedlings in furrows and in V-shaped trenches were not significant; therefore, the expected effect of shading in the furrowed treatment did not materialize. In both treatments, soil settled and reduced the expected difference in survival, particularly in the sandy soil at West Yellowstone. The advantages of trenching were probably twofold: (1) it aided in collecting water and concentrating it, and (2) it protected the seedlings from the hot, dry southwest wind blowing off the Snake River valley. These winds are frequent during the summer at all three study areas. Most seedlings germinated in the bottom of the trenches; those that germinated on the ridges did not survive.

Even though soil surface temperatures reached 150° to 163° F. (65° to 75° C.), direct heat injury to the seedlings proved to be less important than had been expected. Meyer and Anderson[6] had suggested 50° to 60° C. as the thermal death point for most living plant cells. However, soil surface temperatures are not only elusive to measure, but many factors influence minimum lethal temperatures and exposure times.

[5] U.S. Weather Bureau. Climatological data for the United States by sections. Montana section, vols. 53-65, 1950-1962.

[6] Meyer, B. S., and Anderson, D. B. Plant physiology. Princeton, N.J.: D. Van Nostrand Co., Inc. 784 pp., illus. 1952.

Day[7] made an excellent review of literature on this subject. Variation in soil moisture, relative humidity near the seedlings, color of surface material, shading by vegetation, and microslope are some of the more important factors affecting soil surface temperatures. Furthermore, the condition of the protoplasm and internal water relations affect the temperature at which tissue necrosis occurs. The full importance of heat injury as a cause of mortality during hot, dry years on these three physiographic areas will have to be determined by future work.

Although the study was conducted in what appears to have been a favorable year, first-year results permit the following conclusions:

1. Thorough preparation of the seedbed greatly improves germination and survival of lodgepole pine in southwestern Montana and eastern Idaho. The better treatments should provide conditions that will enable survival of one seedling for every 30 to 50 viable seed, whether sown or from a natural supply; i.e., from 30,000 to 50,000 viable seed per acre ought to establish a September catch of 1,000 seedlings per acre.

2. More than 90 percent of the lodgepole pine seedlings germinate early in the season (in a period of 2 to 4 weeks) once conditions become favorable. However, in the Rocky Mountains conditions do not favor germination until late June or early July.

3. A principal cause of first-year seedling mortality in lodgepole pine is drought, even in a relatively cool, wet summer. Therefore, seedbed treatment for optimum lodgepole pine regeneration in southwestern Montana and eastern Idaho should be directed towards conserving soil moisture.

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[7] Day, R. J. Spruce seedling mortality caused by adverse summer microclimate in the Rocky Mountains. Canada Dept. Forestry Pub. 1003, 35 pp., illus. 1963.

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